Effect of Heat Treatment on the Characteristics of SiO2 Added-ZnFe2O4 Ceramics for NTC Thermistors

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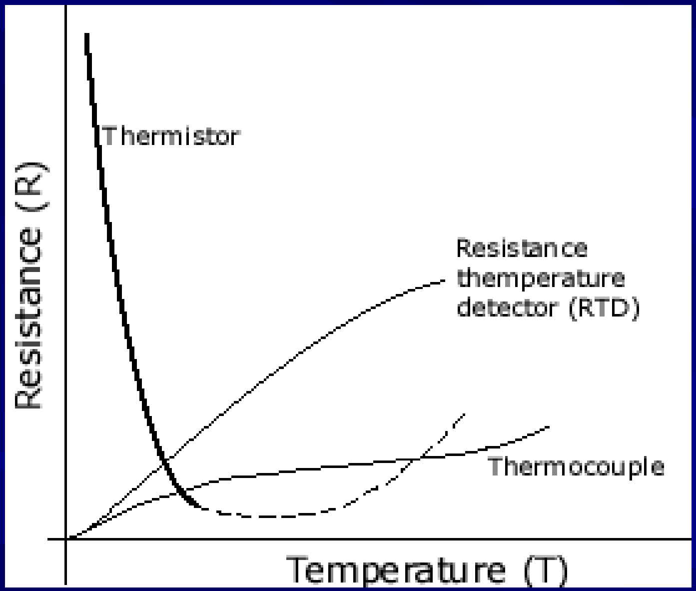
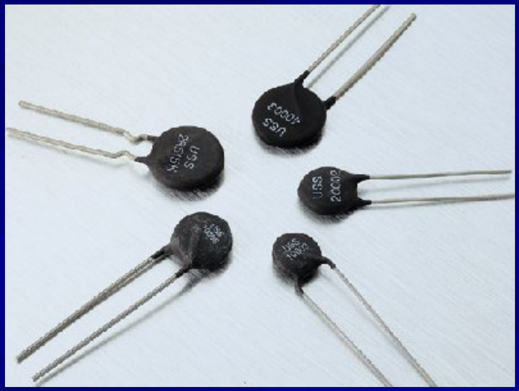
INTRODUCTION

THERMISTOR→ Thermally Sensitive Resistor.

NTC CHARACTERISTIC PRODUCT EXAMPLES APPLICATIONS

R vs T- THERMISTOR





Current limiter thermistor

Specialize Thermistor

Incubator

Computer

INTRODUCTION (Continuation)

- Important electronic component.

  - Sectors: Biomedical, aerospace, instrumentation, communications, automotive and HVACR (Heating, Ventilation, Air conditioning and Refrigeration).

  -Application : Temperature measurement, circuit compensation, suppression of in rush-current, flow rate sensor and pressure sensor.
- Most, thermistors are produced from spinel ceramics based on transition metal oxides forming general formula AB2O4.
- Need alternative {Expecially based on abundant material [yarosit mineral(Fe3O4)] in Indonesia} → $ZnFe_2O_4$ is proposed, including that added with SiO_2.
- Predicted that the heat treatment effect can improve the characteristics of the $ZnFe_2O_4$ ceramic for NTC thermistors.

EXPERIMENT

ZnO

Fe_3O_4

0.5% SiO_2

MIXING

CALCINATION

800^oC/2h

CRUSHING

SIEVING

PRESSING

3,9 ton/cm^2

SINTERING

1200^oC/2h/6^0C/6^0C

Heat Treatment
1000^0C/10'/10^0C/10^0C
1000^0C/10'/10^0C/ 2^0C
1000^0C/10'/10^0 C/quenching

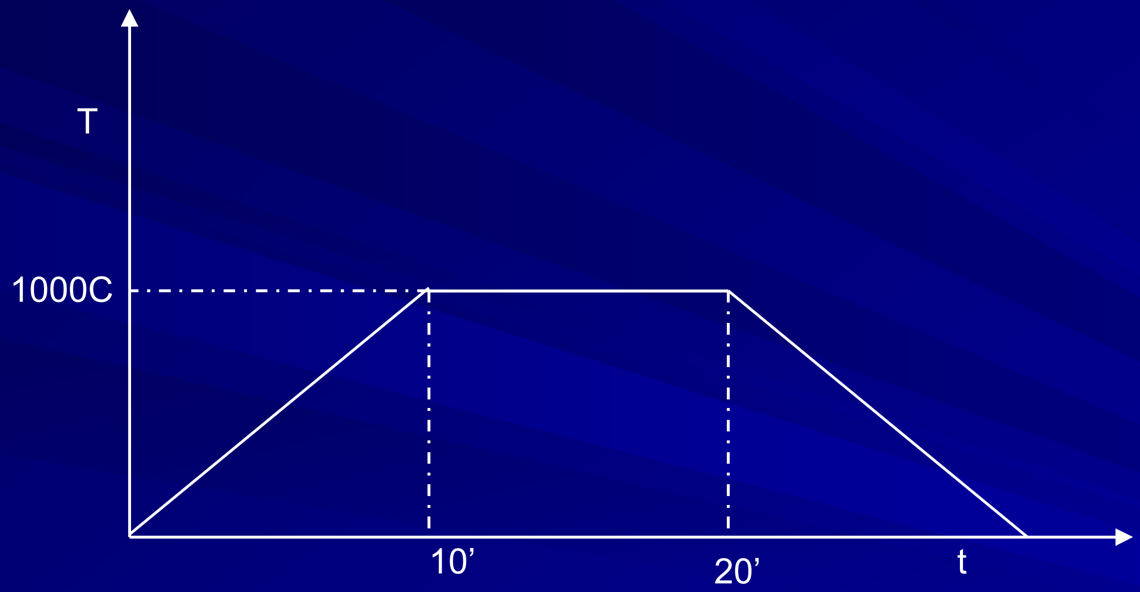
CHARACTERIZATION
-XRD
-Electrical
-Microstructural

Sintering Furnace

Optical Microscope

XRD

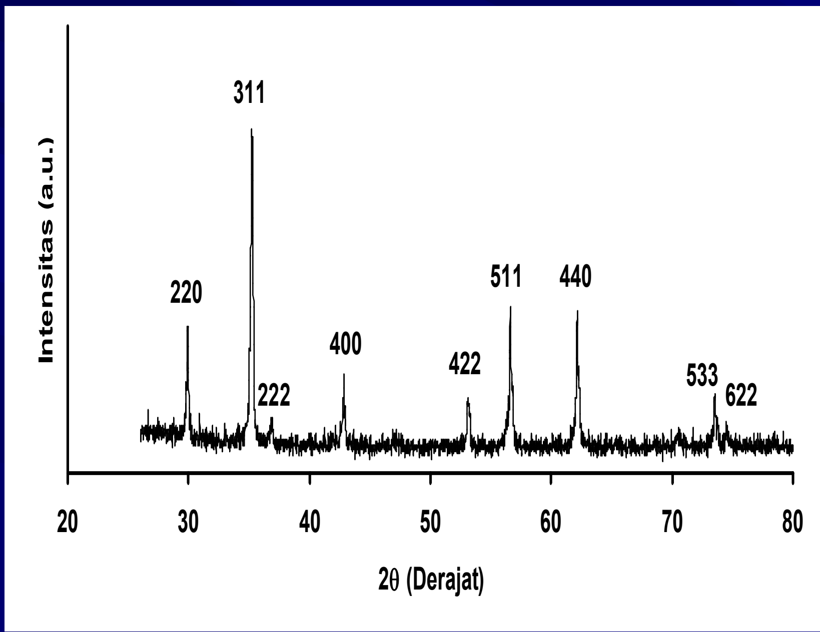
Heat Treatment



1000C/10’/10C/2C
1000C/10’/10C/ 10C
1000C/10’/10C/quenching

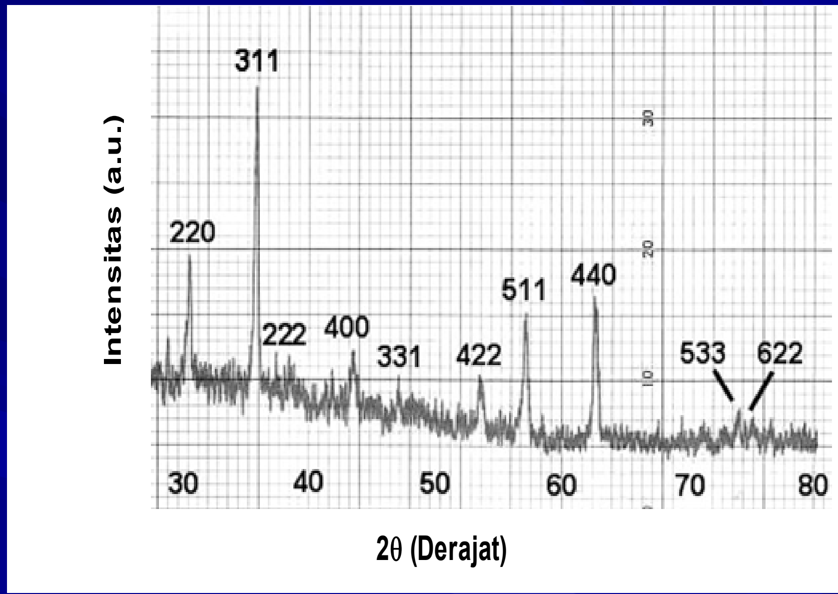
Visual Appearance of typical SiO2 Added-ZnFe204

RESULTS (XRD Profile)



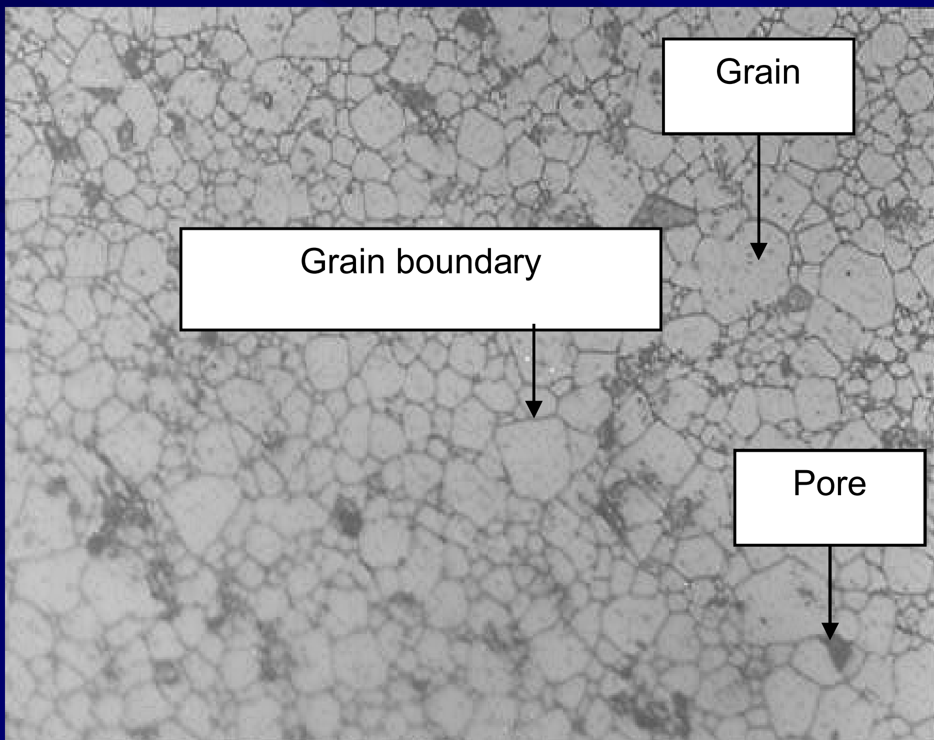
0 w/o SiO2 sintered at 1200 C/2h/6 C/6 C

0.5 w/o SiO2 sintered at 1200 C/2h/6 C/6 C

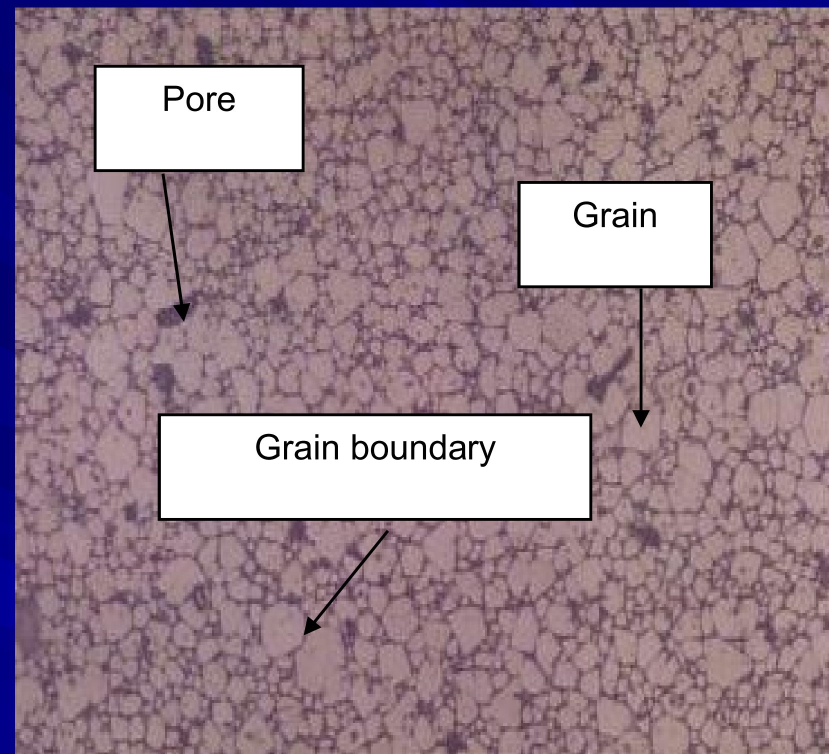


XRD profiles of $ZnFe_2O_4$ based-ceramics.

RESULTS (Microstructure)



0 w/o SiO2 sintered at 1200 C/2h/6 C/6 C



0.5 w/o SiO2 sintered at 1200 C/2h/6 C/6 C

50 μm

Microstructure of the $ZnFe_2O_4$ based-ceramics.

Electrical Characteristic

- $R = R_0 . \text{Exp.}(B/T)$
  - $Ea = B.k$
  - $\alpha = - B/T^2$

R = Thermistor resistance

R_0 = Resistance at the infinite temperature

B = Thermistor constant

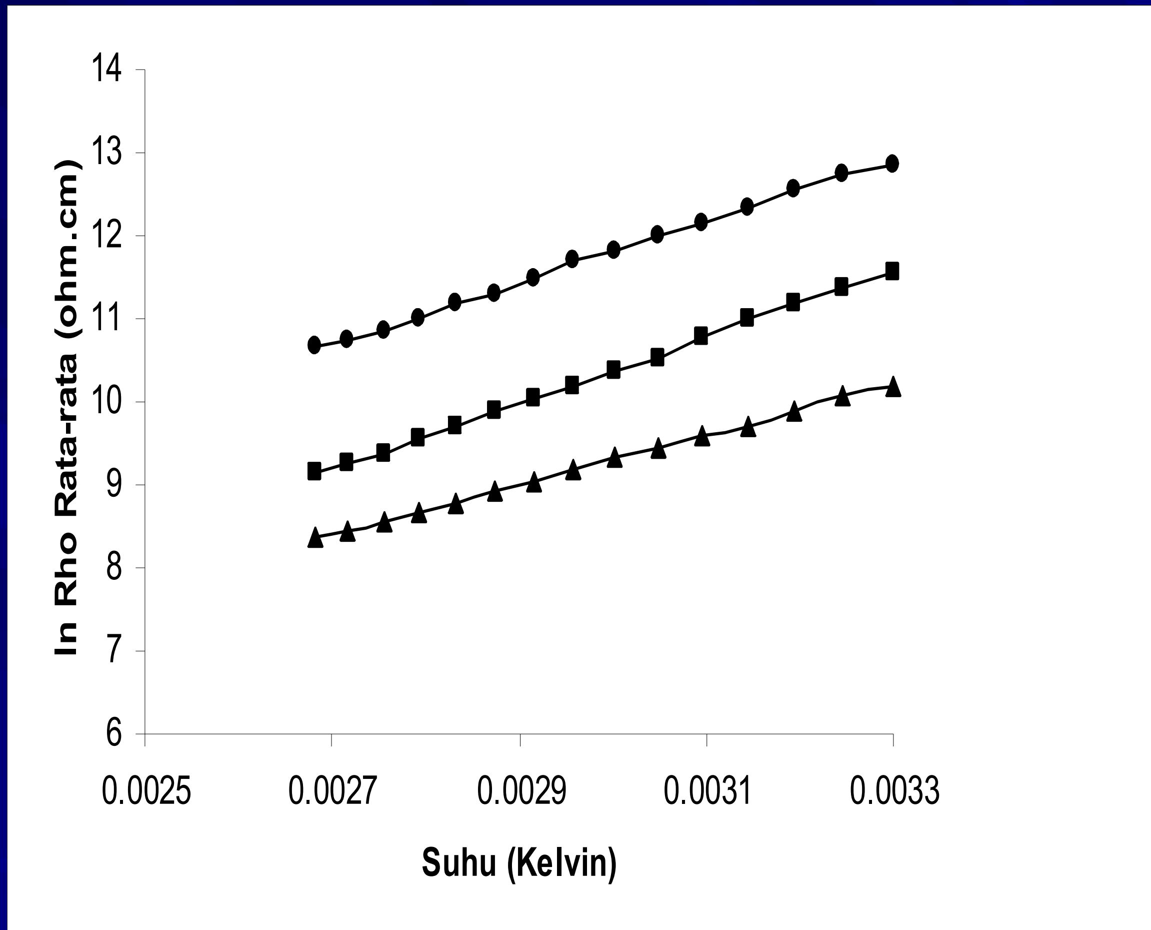
T = Temperature of thermistor

Ea = Activation energy

k = The Boltzmann constant

α = Sensitivity of thermistor

RESULTS (Electrical Characteristics)



Ln resistivity (ρ) vs $1/T$ of SiO_2 added- $ZnFe_2O_4$ ceramics.

RESULTS
(Electrical Characteristics)

No.	Heat treatment	B (^{0}K)	Ea (eV)	α (%/ ^{0}K)	ρ_{RT} (kOhm-cm)
1	Sintered at 1200^{0}C/2hours/6C/6C) (Initial)	-	-	-	98
2	1000 C/10min/ 10C/ 10 C	3978	0.34	4.42	38
3	1000 C/10min /10C/ 2 C	3705	0.32	4.12	154
4	1000C/10min/10C/*quenching*	3014	0.26	3.35	12

Tabel of The value of the thermistor constant (B), sensitivity (α) and room temperature resistivity (ρ_{RT}) of 0.5 weight % SiO_2 added-ZnFe2O4 ceramics.

Market requirement for B is ≥ 2000 ^{o}K and α is ≥ 2.2 %/^{o}K[7], and for ρ_{RT} = 10 ohm.cm -1 Mohm.cm [4].

CONCLUSIONS

- The grain size of the ZnFe2O4 ceramics tends to decrease by addition of SiO2.
- The Heat Treatment can be adopted in thermistor fabrication to control the electrical characteristics of the thermistor.
- The values of the thermistor constant (B) and the room temperature resistivity (ρ_{RT}) of the ZnFe2O4 ceramics made in this work fits the market requirement.

THANK YOU

- **ACKNOWLEGMENT**

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